

### **REMARKS**

Reconsideration of the present application in view of the above amendments and following remarks is respectfully requested.

#### **I. STATUS OF THE CLAIMS**

Claims 5 to 17, 27 and 29 to 31 are presently pending. Claims 13, 15, 17 and 27 have been amended, without prejudice. Applicants hereby reserve the right to pursue such claims as originally presented, or claims of a similar scope, in a related application. The amendments to the claims are supported by the claims as filed and in the specification.

#### **II. THE EXAMINER'S OBJECTIONS ARE MOOTED/OVERCOME**

##### **A. The Objection to the Specification is Overcome**

The Examiner objected to the Abstract of the disclosure as not accurately summarizing the invention. In particular, the Examiner noted that claim 11, the only independent claim, calls for the use of organic filler in the inner layer and inorganic filler in the outer layer of the claimed cable assembly. Applicants overcome this objection with amendments to the Abstract by (1) inserting the phrase "and an organic filler," after the phrase "inner wall of polytetrafluoroethylene," (2) deleting the term "and" after the phrase "inner wall of polytetrafluoroethylene" and (3) inserting the phrase "and a layer of polytetrafluoroethylene disposed therebetween" after the phrase "and an inorganic filler."

##### **B. The Objection to Claim 17 is Overcome**

The Examiner objected to claim 17 under 37 C.F.R. § 1.75 as being a substantial duplicate of allowed claim 11. Applicants overcome this objection with an

amendment to Claim 17 by (1) replacing the phrase "further comprising a" with the phrase "wherein the," and by (2) replacing the phrase "disposed between the inner wall and the outer wall of the tubular article." with the phrase "comprises from about 25 to about 85% of the total thickness of the tubular article."

**C. The Objection to Claim 27 is Mooted**

The Examiner has objected to Claim 27 as having a typographical error. Applicants are grateful to the Examiner for pointing out this obvious typographical error and have amended Claim 27 by inserting a space between the term "11" and the term "wherein."

**D. The Objection to Claim 15 is Mooted**

The Examiner has objected to Claim 15 as improperly depending on cancelled claim 38. Applicants overcome this objection with an amendment to Claim 15 by replacing the term "38" with the term "11."

**III. THE EXAMINER'S REJECTIONS ARE OVERCOME/TRAVERSED**

**A. The Rejection of Claim 13 is Overcome**

The Examiner rejected claim 13 under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter that Applicants regard as the invention. Specifically, the Examiner has stated that claim 13 has no antecedent basis for the glass, iron, oxide and sulfide fillers recited as "organic fillers" because such fillers do not contain carbon. Claim 13 is also rejected as indefinite because the scope of the term "organic fillers" does not include the glass, iron, oxide, and sulfide fillers. Applicants are grateful to the Examiner for pointing out this obvious typographical error. Applicants have overcome the rejections by replacing the term "organic" with the term "inorganic" in claim 13.

Support for this amendment is found in the specification on page 12, paragraph 2.

**B. The Rejection of Claim 14 is Overcome**

The Examiner rejected claim 14 under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter that Applicants regard as the invention. Specifically, the Examiner questioned the meaning in claim 14 of the term "polyether ether ketones" and how this term differed from the term "polyether ketones". Applicants note that such terms are known and distinguishable by those skilled in the art. By way of non-limiting example, please see the attached copy of page 28 from the Modern Plastics Encyclopedia (1989), which has separate headings for these two types of ketone-based materials.

**C. The Rejection of Claim 15 is Overcome**

The Examiner rejected claim 15 under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter that Applicants regard as the invention. Specifically, the Examiner questioned the meaning in claim 15 of the terms "polysulfones" and "polyphenylsulphones". The Applicants note that such terms are known and distinguishable by those skilled in the art. By way of non-limiting example, polysulfones are well known in the art, please see the attached copy of page 109 of the Modern Plastics Encyclopedia (1989), and polyphenyl sulfones are readily understood to be those polysulfones which include a phenyl moiety in the chain.

**IV. CONCLUSION**

In view of the above amendments and remarks, the present application is in condition for allowance and a Notice of Allowance is therefore earnestly solicited.

The Commissioner is authorized hereby to charge any fees or credit any


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Respectfully submitted,

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Joseph F. Posillico, Esquire  
Registration No. 32,290

Synnestvedt & Lechner LLP  
2600 Aramark Tower  
1101 Market Street  
Philadelphia, PA 19107  
Telephone (215) 923-4466  
Facsimile (215) 923-2189

CMM

## Ketone-based resins

### Polyetherketone

by Roger F. Jones

Polyetherketone is a new, partially crystalline, high-performance aromatic ketone-based thermoplastic that is heat-stable and readily processed. As a member of the ketone family it shares with polyetheretherketone such properties as chemical resistance; exceptional toughness, strength, rigidity, and loadbearing capabilities; good radiation resistance; the best fire-safety characteristics of any thermoplastic; and the ability to be easily melt-processed.

#### Chemistry and properties

PEK is a partially crystalline aromatic material composed of aryl repeating units linked by oxygen and carbonyl groups. It has a relative density of 1.32. Some specific benefits PEK offers include the ability to retain 50% or better of its mechanical properties at sustained-use temperatures of up to 482°F.; inherent flame retardancy and extremely low smoke generation, high resistance to a wide range of chemical reagents and hydrolysis, wear- and abrasion-resistance in finished products, and excellent dielectric properties.

Recently developed "super" PEKs designed for advanced composites have continuous service temperature of 500°F., a glass transition temperature (T<sub>g</sub>) of

401°F., and a slow crystallization rate that suit them for processes with slow cooling rates from the melt.

#### Processing and applications

PEK is easily processed by injection molding, extrusion, spinning, cold forming, and machining. It can be melt-processed on standard injection and extrusion equipment; barrel temperatures are in the neighborhood of 725°F.; mold temperatures around 325°F.

Its ease of processability and outstanding properties make PEK suitable for use in the most critical and hostile environments, where it is positioned to challenge metals and other costly materials. Components of PEK are lighter in weight than metals, and can be produced to fine tolerances.

In addition to its promise as a matrix component in advanced composites, PEK is expected to find application in automotive and industrial bearing cages; seals and housings; aerospace cable protection and cladding; and printed circuit boards.

#### Commercial information

PEK is a relatively new material, having been introduced commercially late in 1986. Prices are in the \$15 to \$32/lb. range.

In the U.S., ICI Americas markets PEK under its Victrex tradename; BASF calls its material Ultrapek. West German producer Hoechst is currently introducing its own PEK polymer under the tradename Hostatec. □

### Polyetheretherketone

By H.J. Dillon

Polyetheretherketone is a high-temperature-resistant thermoplastic suitable for wire coating, injection molding, film, and advanced structural composite fabrication.

The aromatic ketone material offers outstanding thermal and combustion characteristics and resistance to a wide range of solvents and proprietary fluids.

#### Chemistry and properties

PEEK polymer is made by condensation polymerization in an aromatic solvent. Its wholly aromatic structure contributes to its high-temperature performance. Its crystalline character gives it important advantages including resistance to organic solvents and dynamic fatigue, and retention of ductility on short-term heat aging.

PEEK is supplied as dry, free-flowing granules and exhibits very low water absorption. Among its properties are:

**Mechanical.** At room temperature, PEEK functions as a typical engineering

thermoplastic. It is tough, strong, rigid, and has good loadbearing properties over long periods. The material has outstanding resistance to both abrasion and dynamic fatigue.

**Thermal.** PEEK's continuous service rating is close to 470°F.; it offers high temperature mechanical properties making it suitable for use at up to 600°F.

**Flammability.** PEEK has a high Limiting Oxygen Index, meets UL 94 V-0 requirements, and demonstrates extremely low smoke emission. It contains no flame-retardant additives or halogens.

**Chemical resistance.** PEEK has good resistance to aqueous reagents, with long-term performance in superheated water at 500°F. Its resistance to attack is good over a wide pH range, from 60% sulfuric acid to 40% sodium hydroxide at elevated temperatures. Attack can occur with some concentrated acids.

No organic solvent attack has been observed on molded parts, although a limited range of solvents will stress-craze, highly stressed PEEK-coated wire. Orientation of

the material below its melting point has been shown to overcome this stress-crazing problem.

**Radiation resistance.** Preliminary tests suggest that radiation resistance is extremely good. Tightly coiled PEEK-coated wire samples have withstood 1100 Mrads without significant degradation. Weathering resistance is currently under evaluation. Tests show no loss of properties after one year of outdoor exposure.

PEEK is available as powder or granules, and in a range of viscosities. Granules can be reinforced with glass, carbon, or special additives for applications such as bearings:

#### Applications

PEEK is used for fine monofilament, film, automotive engine parts, aerospace composites, and wire and cable. New easy-flow grades are designed for injection molding parts with long or complex flow paths or thin sections.

#### Commercial information

Prices currently are in the \$15 to \$32/lb. range, reflecting the material's dependence on costly feedstocks. If ongoing research into the use of more economical feedstocks proves successful, per-pound cost could drop to around \$10 within the next several years.

PEEK is sold in the U.S. by ICI Americas under the Victrex tradename. □

## Nitrile resin

Nitrile resins are polymers, the principal monomer of which is acrylonitrile; this provides the functionality of good gas barrier, chemical resistance, and taste and odor retention properties. The resins have moderately high tensile properties, good impact properties when rubber-modified or oriented, and can be processed by extrusion, injection molding, and thermoforming. They are used principally in the packaging of foods other than beverages, and in nonfood packaging in the U.S. and abroad.

#### Chemistry and properties

The chemical composition of nitrile resins includes about 70% by weight of acrylonitrile monomer, 20 to 30% methylacrylate or styrene as the comonomer, and 0 to 10% butadiene as the impact-modifying monomer.

Mechanical properties of nitrile resins include tensile strength at yield in the 9000 to 10,000 p.s.i. range, elongation at yield of 3 to 5%, and flexural modulus of 450,000 to 500,000 p.s.i. Notched Izod impact is 1.5 to 2 ft.-lb./in. for impact-modified injection molding grades, and 2 to 4 ft.-lb. for impact-modified extrusion grades. Notched Izod for the unmodified nitrile resins is in the range of 0.2 to 0.5 ft.-lb./in., but impact resistance can

H.J. Dillon is Communications Manager, ICI Americas Inc., Wilmington, DE 19897.

Article contributed by B.P. Chemical International, 200 Public Sq., Cleveland, OH 44114-2375.

good and can be significantly improved by heat treatment.

Thermal stability is outstanding with a useful life of 4 to 5 yr. at 390°F. and approximately 20 yr. at 356°F.

PES has inherently low flammability and meets UL 94 V-0 requirements at thicknesses of 0.017 in. and above. The limiting oxygen index is in the range of 38 to 42%. Under burning conditions, PES has very low smoke emission as measured by the NBS smoke chamber test and performs excellently (i.e., less than 65/65) in the OSU test, which will be introduced in 1990 by the FAA for aircraft interiors.

It shows good resistance to most inorganic chemicals, oils, greases, aliphatic hydrocarbons, and gasoline at ambient and elevated temperatures.

Most proprietary cleaning solvents do not attack it unless the components are heavily stressed; known exceptions are esters, ketones, methylene chloride, and polar aromatic solvents. It has been tested against a wide variety of organic solvents, including chlorinated and fluorinated reagents.

PES can be plated by an electroless nickel or copper process and peel strengths of 10 lb./in. obtained, sufficient to withstand wave soldering at up to 550°F. without warping.

#### Grades

Unfilled PES is available in transparent and opaque colors in both injection molding and extrusion grades.

A range of grades is available to meet special requirements. Easy flow unfilled and glass-filled grades are available for difficult moldings involving thin sections and/or long flow lengths. Modified forms offer improved mold release properties.

Several compounds are formulated for bearing applications. Special grades for metal plating and three-dimensional circuit boards are offered, as are coating formulations intended for decorative nonstick applications.

#### Processing

Even though PES is a high-temperature thermoplastic, it can be processed on conventional equipment. Therefore injection molding, extrusion, blow molding, compression molding, and vacuum or pressure forming are applicable techniques.

High mold temperatures generally assist mold fill and reduce molded-in stresses.

Because PES is amorphous, mold shrinkage is low and it therefore is suitable for applications requiring close tolerances and little dimensional change over a wide temperature range.

#### Applications

Both unfilled and glass-filled grades of PES used are for high-temperature electrical multipin connectors. Other electrical applications include coil bobbins, integrated circuit sockets, edge and round multipin connectors, terminal blocks, printed circuit boards, and DIP switches.

The material's mechanical strength ac-

counts for its use in radomes, pump housings, bearing cages, and power saw manifolds. Small appliance manufacturers have chosen PES for hair dryer outlets, hot combs, and projector lamp grilles. Transparency has led to its use in indicator lights and sight glasses; because the material is sterilizable, there are many medical applications. It is suited for aircraft components and graphite- and glass-reinforced composites.

Glass-reinforced PES is being used for conductivity cells, water meters, and pumps at temperatures up to 300°F. in superheated water.

#### Commercial information

Pricing for standard grades of PES resins is \$4.25 to \$6.50/pound. The material is marketed in the U.S. and throughout the world by ICI Advanced Materials under the Victrex tradename; BASF sells it in certain European countries under the name Ultrason E. □

## Polysulfone

By L.A. McKenna

Polysulfone is a transparent, heat-resistant, ultra-stable high-performance engineering thermoplastic. It is amorphous in nature and has low flammability and smoke emission. It possesses good electrical properties that remain relatively unchanged up to temperatures near its glass transition temperature (374°F.).

These features are a result of the molecular structure of polysulfone, primarily the diaryl sulfone group. This group tends to attract electrons from the phenyl rings. Oxygen atoms para to the sulfone group enhance resonance and produce oxidation resistance. High resonance also strengthens the bonds spatially, fixing the grouping into a planar configuration. The polymer consequently has good thermal stability and rigidity at high temperatures. Ether linkages provide chain flexibility, thereby imparting good impact strength.

The polymer resists hydrolysis and aqueous acid and alkaline environments, because the linkages connecting the benzene rings are hydrolytically stable.

PSO can be processed on conventional thermoplastic processing machinery and requires high processing temperatures. It must be dried before molding, extrusion, or thermoforming.

#### Properties

PSO has high resistance to acids, alkalis, and salt solutions, and good resistance to detergents, oils, and alcohols, even at elevated temperatures under moderate stress. It is attacked by polar organic solvents such as ketones, chlorinated hydrocarbons, and aromatic hydrocarbons.

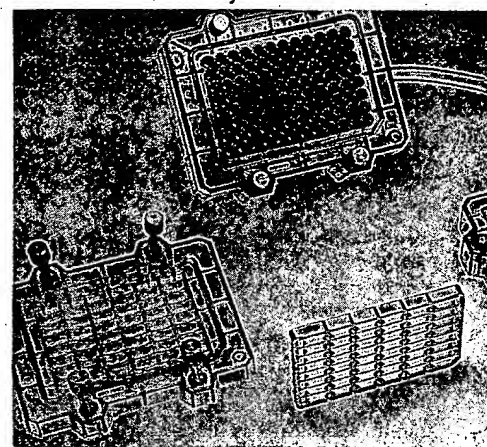


Fig. 1: Medical-grade PSO withstands repeated sterilization procedures. [Photo, Amoco]

PSO can be used continuously in steam at temperatures up to 300°F. Maximum stress in water at 180°F. is about 2000 p.s.i. for steady loads and 2500 p.s.i. for intermittent loads. To optimize long-term transparency and impact resistance, the maximum stress in water at 180°F. is about 500 p.s.i. under steady loads and 1000 p.s.i. for intermittent loads. Lower water temperatures permit higher stresses: for example, at 72°F., the recommended maximum working stresses are 3000 and 3500 p.s.i. for steady and intermittent loads, respectively.

After 10,000 hr. at room temperature, at 3000 p.s.i. stress in air, the creep (strain) of polysulfone is only 1%. After a full year at 210°F. and 3000 p.s.i., total strain is well below 2%.

In long-term performance at 300°F., PSO increases about 10% in strength and modulus values, retaining 90% of its dielectric strength and 70% of its impact strength. PSO has a tensile impact strength of 200 ft.-lb./sq. in. The first few months of exposure to high temperatures, such as 300°F., produce an annealing effect which reduces these values by about 30%. These properties remain essentially constant throughout the remainder of a 2-yr. test period.

Underwriters Laboratories has listed polysulfone for continuous service at 320°F. It will withstand higher temperatures intermittently since its Tg is 374°F. Amoco's Udel PSO is sanctioned by the FDA for food contact in single- and multiple-use applications.

PSO offers a good combination of electrical properties: dielectric strength and volume resistivity are high, while dielectric constant and dissipation factor are low. The latter two properties (which determine lossiness) remain relatively constant over wide ranges of temperatures and frequencies (including microwave frequencies).

PSO can be plated by an electroless nickel or copper process that imparts bond strength above 20 lb./inch.

L.A. McKenna is Senior Development Scientist, Applications Development & Technical Service, Amoco Performance Products, Inc., P.O. Box 409, Bound Brook, NJ 08805.